

other end, the IF signal is reconstructed, and then up-converted back to RF.

The down-conversion and up-conversion are implemented by mixing the signal with a local oscillator (LO). In order for the original frequency of the signal to be restored, the signal must be up-converted with an LO that has exactly the same frequency as the LO that was used for down conversion. Any difference in LO frequencies will translate to an equivalent end to end frequency offset. In the embodiment described above, the down conversion and up conversion LO's are at locations remote from one another. Therefore, in one preferred embodiment, frequency coherence between the local and remote LO's is established as follows: at the host end, there is a 552.96 MHz master clock which establishes the bit rate over the fiber. This clock also generates a 30.72 MHz clock ( $30.72=552.96+18$ ), which serves as a reference to which the host digitizer LO's are locked.

At the remote end, there is another 552.96 MHz clock, which is recovered from the optical bit stream with the help of a phase lock loop. Because this clock is recovered from the bit stream generated at the host, it is frequency coherent with the master clock. A 30.72 MHz clock is then generated to serve as a reference for the remote local oscillators. Because the 552.96 MHz clocks are frequency coherent, so are the 30.72 MHz references, and any LO's locked to them, thus ensuring that host and remote LO's are locked in frequency.

Referring now to FIGS. 46 and 47, there is shown yet another alternate exemplary embodiment to the sectorized microcell system according to the present invention. In this embodiment, sectorized base station unit 906, provides that an analog-to-digital multiplexer and digital-to-analog demultiplexer unit 960 receives a separate input from each of the channel banks 912, and separately converts each of the RF composite signals from the channel banks to a corresponding digitized RF stream. This digitized RF stream is in turn multiplexed into a single digitized stream, which is output in optical form for application to wave division multiplexer 916. In the reverse direction, a single digitized RF stream is received from wave division multiplexer 916, and demultiplexed into N separate digital streams, each corresponding to one of N sectors (where  $N=3$  in the example shown in FIG. 42). Each of the digital streams represents a desynchronized of the analog RF received by the respective sector antenna in pair 902. The demultiplexed digital stream is then converted from digital-to-analog form, and applied to each of the respective receivers in the channel banks 912.

FIG. 47 illustrates an alternate embodiment of remote unit 904 of FIG. 42. Remote units 900 of FIG. 47 include a multiplexer/demultiplexer unit 970, which receives the digitized stream from wave division multiplexer 930, and converts the multiplexed digitized signals from each of the respective banks in the sectorized base station unit 906 shown in FIG. 46. The demultiplexed data streams for each of the banks is applied to respective digital-to-analog and analog-to-digital conversion units 972 which convert the digitized signal to a corresponding analog RF signal. The analog RF signal is applied to an amplifier 938, which is in turn applied to band pass filter 940 and to transmitter antenna 902a, in a manner similar to that described for FIG. 44. Similarly, RF receiving antenna 902b is applied to band pass filter 942, which in turn applies its output to unit 972, wherein the analog signal is converted to a digital form for application to multiplexer/demultiplexer 970. The digitized data streams from each of units 972 is multiplexed in unit

970, converted to an optical output, and applied to wave divisional multiplexer 932, for transmission over fiber 905 to sectorized base station unit 906 of FIG. 46. The digitized data stream is received by wave division multiplexer 916, in sectorized base station unit 906 of FIG. 46, applied to unit 960. Unit 960 demultiplexes the digitized stream into a digital stream associated with each sector and converts each sector digital stream to a sector RF signal. The sector RF signal is applied to the receivers of the respective channel banks for the sectors.

Thus, the sectorized microcell system of the present invention allows for the replacement of the conventional cell site base station in a convention macrocell. In the above described embodiments, the antennas used for each sector are directional, and are all located in the same place. Each directional antenna, one transmit and receive for each sector, is then directed outwardly across the sector serviced by them. For instance, the sectors may be pie-shaped, with the directional antennas positioned at the center of the pie. Alternatively, nondirectional antennas could be used and positioned at different locations in the cell site. In such a case, the antennas are coupled to the cell site through coaxial cables. In addition, though the above sectorization examples have been described using antenna pairs, it should be obvious to one skilled in the art that sector units having one antenna, or even units having three or more antennae may be used advantageously within such a system. Furthermore, although the examples described entail only the digitization of RF signals generated from the telephone signal received from the MTSO, it should be apparent that the techniques of digital synthesis described in the context of FIG. 10 et al. also apply to a sectorized microcell system. Diversity channels may also be implemented as described above.

Finally, although each of the examples above describes the use of an analog RF signal transmitted and received by each remote unit, it should be obvious that the above system and method can be applied advantageously to a digital RF cellular system in a manner well known in the art.

Thus, as described above, the sectorized cell replacement system provides for greater reuse of channels, by dividing conventional cells or even microcells into a plurality of sectors. Furthermore, the system provides all the benefits and advantages of the microcell systems described hereinabove, wherein the transmitters and receivers for all the channels in the cell are centrally located in a convenient and inexpensive location.

Thus, as described above, the present inventions provide a variety of digital systems and methods for transporting cellular traffic to and from antenna units, and for passively switching. Although the invention(s) has been described in its preferred form, those of skill in the art will recognize that many modifications and changes may be made thereto without departing from the spirit and the scope of the claims appended hereto.

We claim:

1. A method of sectorizing coverage over a cellular communications area divided into a plurality of microcells each covering a subarea of the communications area and being divided into a plurality of angular sectors having separate transmitters and receivers, the method comprising performing the following steps:

receiving a number of information-bearing telephone signals from a mobile telecommunications switching office at a common base station serving the microcells within the cellular communications area;

modulating the information-bearing telephone signals onto a plurality of different analog radio-frequency

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carriers representing a plurality of different channel sets for respective sectors of the microcells at the base station;

combining the analog radio-frequency signals for all of the sectors into a single outbound analog signal within a predetermined radio-frequency band, representing all of the channel sets for all of the sectors;

converting the single outbound analog signal directly to a single outbound digital representation at the base station;

sending the outbound digital representation of the radio-frequency signal via a transmission means to a remote unit located in or near the subarea of at least one microcell;

at the remote unit, converting the outbound digital representation directly to a single analog representation of the entire outbound single radio-frequency signal within the same radio-frequency band and containing each of the plurality of channel sets;

sending each of the plurality of channel sets to a different one of a plurality of antenna units for the microcell, each of the antenna units being positioned so as to cover a different angular sector of the microcell;

at the antenna unit covering each sector of the microcell, receiving telephone signals within the radio-frequency band for the channel set of that sector;

sending the received telephone signals to the remote unit;

at the remote unit, combining all the received telephone signals from all the sectors to a single combined analog radio-frequency received signal containing all the channel sets for the microcell;

converting the single combined radio-frequency received signal directly to a received digital representation of the radio-frequency band of the channel sets for the sectors;

sending the received digital representation via the transmission means to the base station; and

at the centrally located base station, converting the received digital representation directly to a received analog representation;

demodulating the received analog representation to recover the individual inbound telephone signals.

2. The method of claim 1, wherein:

the step of sending the digital representation of the radio-frequency signal to the remote unit includes modulating it onto a transmit optical signal at a transmit wavelength on an optical fiber; and

the step of sending the received digital representation to the base station includes modulating it onto a receive optical signal on an optical fiber.

3. The method of claim 2, wherein the transmit and receive optical signals are sent on the same optical fiber, the transmit and receive wavelengths being different from each other.

4. The method of claim 1, wherein all the antenna units are located near the remote unit, and wherein the distance from the centrally located base station to the remote unit is greater than the distance from the remote unit to its antenna unit.

5. A method of sectorizing coverage over a cellular communications area divided into a plurality of microcells each covering a subarea of the communications area, and

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each divided into a plurality of sectors, the method comprising performing the following steps for each microcell:

receiving a number of information-bearing telephone signals from a mobile telecommunications switching office at a common base station serving the microcells within the cellular communications area;

generating from the information-bearing telephone signals one of a plurality of different channel sets of signals for each sector of that microcell at the base station;

combining the plurality of different channel sets into a single analog signal in a predetermined radio-frequency band;

converting the single analog signal directly to a single digital representation;

sending the digital representation via a transmission means to a remote unit located in or near the subarea;

at the remote unit, converting the digital representation directly to an analog representation of the radio-frequency signal for all channel sets within the same predetermined radio-frequency band; and

sending the radio-frequency signal for each of the plurality of channel sets to a different one of a plurality of antenna units, each of the antenna units being positioned so as to cover a different angular sector of that microcell.

6. The method of claim 5, wherein the step of sending the radio-frequency signal for each of the channel sets includes:

splitting the channel sets to form multiple parallel paths each carrying a signal representation for a different one of the channel sets; and

filtering each of the paths differently based upon the channel set carried on that path.

7. A method of sectorizing coverage over a cellular communications area divided into a plurality of microcells each covering a subarea of the communications area, each microcell being divided into a plurality of sectors, the method comprising:

at a plurality of antenna units each covering a different sector of a microcell, receiving analog telephone signals within a predetermined radio-frequency band for a channel set assigned to that sector;

sending all the analog telephone signals to a remote unit serving the sectors of the microcell, the remote unit being located in or near the subarea of the microcell;

at the remote unit for the microcell, combining all the analog telephone signals from all sectors of the microcell into a single analog signal within the same radio-frequency band as the channel sets for the sectors of the microcell;

converting the single combined analog signal directly as a whole to a received digital representation;

sending the received digital representation via the transmission means to a common base station serving the microcells of the communications area;

at the base station, converting the received digital representation to an inbound analog signal within the radio-frequency band;

demodulating the inbound analog signal to recover a plurality of information-bearing signals representing received analog telephone signals; and

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sending the information-bearing signals to a mobile telecommunications switching office.

8. The method of claim 7, wherein the antenna unit for said each microcell includes one or more diversity antenna (s) covering one or more sector(s) of that microcell.

9. The method of claim 8, further comprising the steps of:  
at each diversity antenna, receiving analog diversity signal(s) within the radio-frequency band for the channel set of its sector;

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sending all diversity signals for said each microcell to the remote unit for said each microcell;

at the remote unit for said each microcell, converting the diversity signals from all sectors in that microcell to a diversity digital representation within the radio-frequency band; and

sending the diversity digital representation via the transmission means to the base station.

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